Sesachacha Pond
Annual Report
2005

Prepared for:
Marine and Coastal Resources Department
34 Washington St.
Nantucket, MA. 02554

Prepared by:
Keith L. Conant
Town Biologist

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Introduction:

Sesachacha Pond is a coastal eutrophic salt pond located on the northeast part of Nantucket Island. It is a kettle pond, formed during the last glacial period. It has two deep basins, (15-18ft. deep) on the northern and southern end. This unique physical characteristic of Sesachacha Pond allows it to support high salinity conditions when the pond is properly opened, and flushed to the sea.

The drainage basin of Sesachacha Pond covers approximately 800 acres. The watershed to pond ratio is low (3:1). The surface area of the pond during "normal conditions" covers 266 acres. The "flooded conditions" of the pond covers 279 acres. The approximate pond volume for "normal" and "flooded" conditions is 2,183 acre-ft and 3,129 acre-ft, respectively.

Development in the pond's watershed has increased nutrient loading to the pond, via groundwater and surface runoff. Nitrogen, a limiting nutrient in salt water conditions, has reached extremely high levels in the pond, severely degrading water quality conditions. The lack of flushing during some pond openings has resulted in higher concentrations of nutrients, low oxygen events, phytoplankton blooms, and fish kills (2002).

Water quality is continuing to degrade over time. Sesachacha Pond was first placed on the Massachusetts 303d list in 1998, for impaired water bodies. Sesachacha Pond has not met the standards for the direct consumption of shellfish due to pathogens since 1988 (Division of Marine Fisheries). The Department of Environmental Protection is the governing agency for impaired water bodies, and has included Sesachacha in the DEP Estuaries Project. This program will determine nutrient thresholds for the pond, and was scheduled to be completed by the School for Marine Science and Technology (SMAST) by June 2004. In 2002 SMAST conducted some preliminary studies and found the pond to be in poor health, exhibiting hyper-eutrophic conditions with average total nitrogen levels at 1,200 ppb. In their Critical Indicator Interim Report, they classify water bodies being of significant impairment when TN levels are between 700-800 ppb.

Historically, Sesachacha was opened to the ocean seasonally to enhance marine fisheries. Pond openings were discontinued for ten years, from 1981-1991. The absence of the openings resulted in an environmental change, moving from marine to a fresh water ecosystem. Sesachacha Pond has been monitored since 1980 for water quality conditions by a variety of agencies. The consulting firm, Perkins Jordan, Inc., completed the first, most thorough study in 1985. At that time the water quality analysis indicated the pond as a mesotrophic system, in good to fair health with average TN levels at 460 ppb. The report also concluded that, not opening the pond would result in a complete freshening of the pond over time. That freshening would result in stress and death to marine life in the pond. They also found what appeared to be a clay layer, buffering the groundwater table from the saline conditions in the pond; which also maintained well water purity.

At that time, they believed that the limited number of septic systems, were not negatively influencing the pond. However, nitrates and phosphates were expected to build up over time, if the pond were not flushed to the ocean. As years passed, and the pond began to freshen, phytoplankton blooms began to occur more frequently. Fish kills began to occur during the summer months, and associated odors became more prominent. The community around Sesachacha Pond became increasingly aware of these environmental conditions, and their involvement eventually lead to public demand to reopen the ponds. This movement evolved into political pressures at the federal level to grant a “home rule petition” to the Town of Nantucket to open the great ponds (1991).

Sesachacha must remain open to the ocean for at least a week, to ensure a proper volumetric exchange of water. In (2005), the pond was opened three times. Fear of flooding lead to an additional opening, which occurred in the winter (2/16-2/24). Because of low water temperatures at this time, many hundreds fish, of several species were stranded on the banks when the water level was lowered; apparently caught off guard, in a state of torpor. The spring opening lasted 6 days, from 4/26 to 5/2, during which, herring were seen running into the pond. The fall opening lasted only one day, 10/28 to 10/29, closing prematurely due to a severe onshore storm. Neither the winter, spring nor the fall openings successfully replaced enough ocean water, for pond water to dilute nutrient concentrations, maintain marine fisheries, or increase salinity.

Increased development to the north of Sesachacha Pond has increased nutrient loading into Sesachacha Pond. Surface runoff and groundwater carry nitrogen and phosphorus to the pond changing water chemistry. Most of the development (80%), around Sesachacha Pond is located in a glacial moraine known as the Plymouth-Evesboro Association. The permeability of this soil type, made up from glacial till and outwash deposits is rapid. Septic tanks placed on the downward slope to the pond will increase seepage of effluent into the pond and groundwater. Nutrients are thus entering Sesachacha Pond though groundwater infiltration. This accelerated eutrophication process has made pond openings more critical in maintaining good water quality. A proper exchange of nutrient latent pond water with alkaline-rich ocean water is now important in maintaining good water quality for marine life.

The Sesachacha water quality monitoring stations are as follows: **Site 1:** Deep basin, north side of pond, also referred to as Quidnet north corner, **Site 4:** Deep basin, south side of pond, also referred to as oyster bed south corner. These locations are designated on **Map #1.**

Sesachacha Pond Monitoring Results:

Appendix A: contains all physical and chemical water quality data. **Appendix B:** contains the averages of A with corresponding charts. **Appendix C:** contains average monthly rainfall for 2005, as collected by the Nantucket Water Company.

Temperature and Dissolved Oxygen:

Temperature and dissolved oxygen are often closely related, and inversely proportional. The solubility of oxygen in water is very dependant on the temperature, and will decrease as temperature rises. Dissolved oxygen (D.O.) is also affected by nutrients, and the biological oxygen demand (BOD) of decaying plant or animal matter. As nutrients increase, phytoplankton and macro algae increase proportionately. These plants have a relatively short life cycle, and when they die and sink to the bottom, they are consumed by anaerobic bacteria. These bacteria consume oxygen, and may lead to anoxic events. When this occurs, nutrients are released from the sediments, and a process known as "internal recycling" begins. The process of eutrophication may occur naturally, but at Sesachacha Pond it is accelerated by anthropogenic uses.

Temperature in the pond follows a well defined bell curve, as expected, rising in the spring and dropping off in the fall. Sesachacha is not very deep, and because of it's shape, it is very well mixed. For these reasons it is predominantly isothermic at all stations and depths. The D.O. follows a converse image of temperature, (Figures 1, and 2), except for the month of July. During this month temperatures peak at an average of 24.7^{o} C, but the average D.O. experiences a temporary spike, with next to normal average readings around 7 mg/l. This may be directly related to the sharp decline of rainfall in June (Figure 4), and the resultant affect on salinity and nutrients in the runoff. Rainfall, salinity and nutrients will be discussed in later sections.

The D.O. was relatively good throughout the sampling period of 2005, and only one recording was taken that would indicate a stressed condition for marine animals. The bottom at Site 4, in August, recorded a value of 2.58 mg/l. All other recordings did not drop below 4 mg/l. This is most likely due to the successful openings in 2003, and 2004. And though this is good, it does not account for the negative cumulative effect of the ever increasing nutrient levels; and the lack of exchange with ocean waters in 2005.

Figure 1: Average Temperature 2005

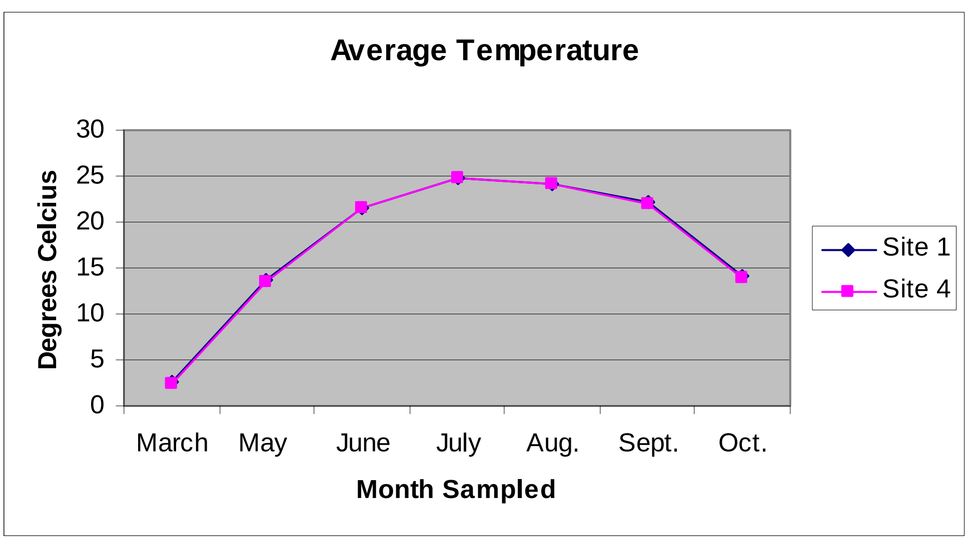
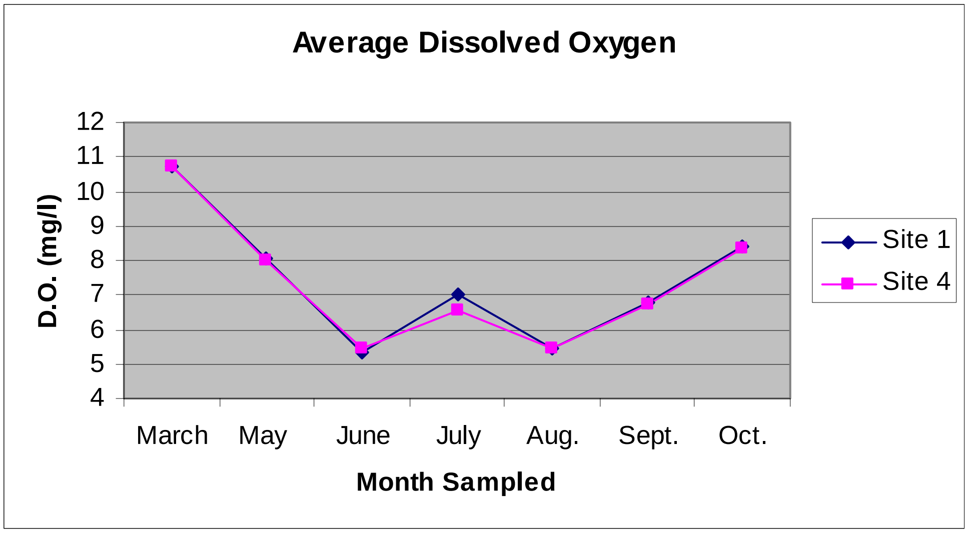


Figure 2: Average Dissolved Oxygen 2005



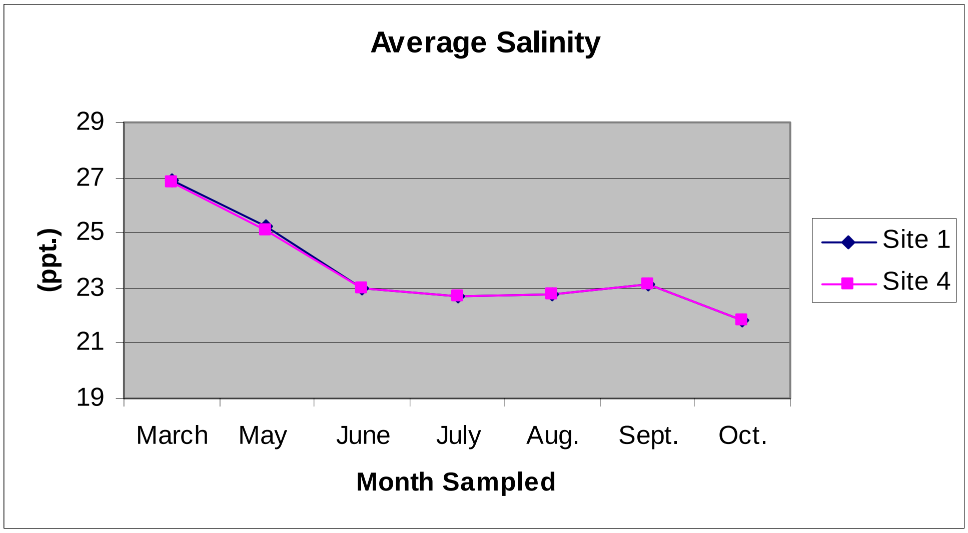
Salinity:

Sesachacha Pond has been designated to be maintained as a salt water pond. Because of it's geomorphic features, and watershed ratio, the pond's deep basins are capable of retaining a high level of salinity. However, if not properly maintained by prolonged openings, its health will rapidly deteriorate. Marine fisheries are susceptible to changes in salinity, and many species have varying salinity regimes throughout their life cycle. Water quality declines rapidly in this pond when an open exchange is not met for at least a week. Successive years of poor openings lead to a fish kill in the summer of 2002. The salinity in the pond for the past three years prior to this event had dropped to an average below 15 parts per thousand (ppt).

Salinity in the pond is representative to the health of the pond. Lower salinities reflect poor openings, with less exchange to the ocean. This lack of exchange also leads to a build up of nutrients, which then cause a further decline in water quality. An exceptionally good opening in the spring of 2003 kept the pond open for approximately a month. This high salinity, above 25 ppt. was maintained for two years, but has started to decline in 2005. An appreciably head volume prior to an opening in the spring seems to be the deciding factor whether these openings go well or not. Fall openings historically have not been successful due to the lack of precipitation in summer months. In 2005 there was an extra winter opening, which decreased this volume, coincidentally the pond has freshened considerably.

There were three openings in 2005, the dates were as follows, 2/16-2/24, 4/26-5/2, and 10/28- 10/29. When sampling began in March the salinity was 27 ppt., by June it had dropped off to 23 ppt. Salinity remained steady throughout the summer, until precipitation picked up again with 3'' of rain in September and 6" of rain in October. Rainfall does appear to have a direct influence on pond salinity, and figures 3, and 4 will show this relationship. Increases in precipitation will cause decreases in salinity, and if good exchanges are not met, especially in the spring, then water quality will decrease.

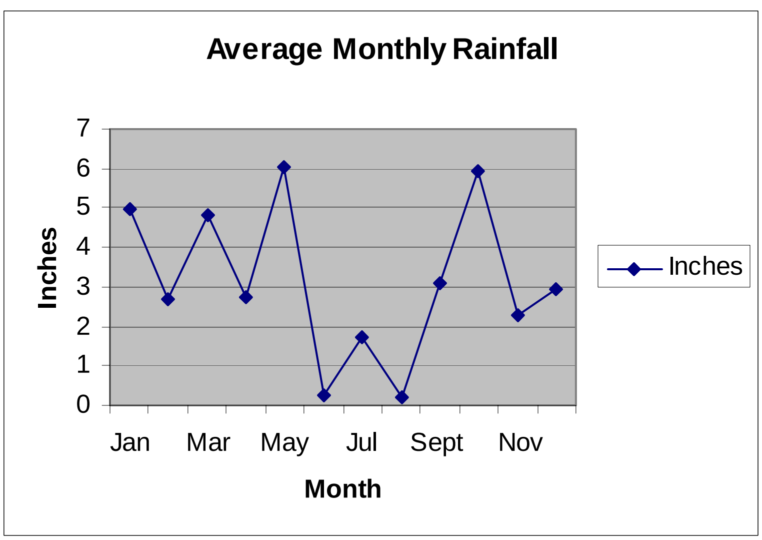
Figure 3: Average Salinity 2005



Rainfall:

Average rainfall was collected by the Nantucket Water Company, and shows considerable precipitation in the spring, and fall. As previously discussed rainfall directly affects volume and salinity in the ponds. It also affects the amount of nutrients that are carried in groundwater flow from watersheds to their associated water bodies. As anthropogenic uses increase, rainfall becomes an important factor in determining water quality.

Figure 4: Average Monthly Rainfall 2005

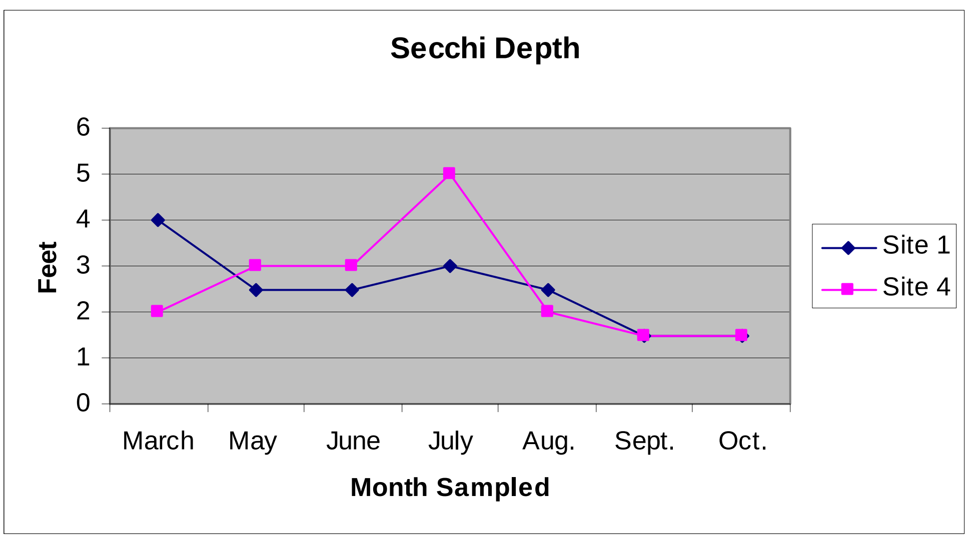


Secchi Depths:

Secchi disk depth recordings are a quick helpful test in measuring water clarity. Water transparency will indicate the amount of phytoplankton, algae, and nutrients available in the water column. The disc measures one half the visible light penetrating the water column. When you combine this information with the bathymetry of any given water body, you can define aquatic plant growth boundary lines. Because of Sesachacha Pond's salinity, and water quality, it has a relative low abundance of submersed aquatic vegetation. The salinity appears to be too high to maintain fresh water pond weeds, and too low to support eel grass. With nutrient levels as high as they are, Sesachacha has become a phytoplankton dominant ecosystem.

Secchi disk depths are on average pretty low in this pond. This is primarily due to phytoplankton production, which is the result of high nutrient levels. Site 1 near Quidnet started at 4' in March then continued to drop to below 2' for the last two months sampled. Site 4 on the golf course side started at 2', then showed an increase in July to 5'; after which, the Secchi disk depth dropped to match those of Site 1. The July spike matches a D.O. spike at the same time, which may be related to a leveling of salinity and a complete drop in NO3, which would have decreased phytoplankton productivity. However it may also be related to some wind driven phenomenon. Once again flushing of the pond with a good exchange of salt water is important in maintaining water quality and clarity. In 2004 Secchi disk depths were better, and reached 8', and 7' in May, and June. This coincides with the favorable openings that occurred in '03 and '04, when the pond stayed open longer with a better exchange of water.

Figure 5: Secchi Depth 2005



Nutrients:

Nitrogen:

Sesachacha Pond is a salt water pond, and as such it is limited by nitrogen with respects to nutrients and plant growth. Nitrogen levels in the pond are exceedingly high. When sampling began in March, total nitrogen levels showed that a state of significant impairment, (as defined by recent SMAST studies), already existed in the pond, (@ or < 700 ppb TN), (Figure 7). Total nitrogen is comprised of inorganic nitrogen, or nitrate (NO3), nitrite (NO2), ammonia (NH3),and organic nitrogen (TKN). NH3 when sampled was below the reportable limit (100 ppb) for all rounds (Appendix A). NO3 is commonly associated with chemical fertilizers, and TKN is most often associated with decaying matter, and septic effluent. TKN takes longer to break down, and so is not as readily available for plant production as NO3. Because of this, TKN is more easily detectable, and reportable in a chemical analysis. As such it is the predominant contributor to the reportable levels of nitrogen in TN.

After March, TN concentrations continued to rise in the pond for the duration of the sampling period. An intermittent spike occurred at Site 4 in August, when TKN jumped to it's highest recorded level 1,820 ppb (Appendix B). July and August are coincidentally the months of peak visitation to the island. However this spike in TN is more likely the result of anoxia occurring on the bottom during respiration. The D.O. on the bottom at Site 4 in August was 2.58 mg/l (Appendix A), this could have led to a release of nutrients from the mud on the bottom; initiating a recycling process of nutrients into the water column.

Nitrate NO3, was initially very high in March when sampling began (Figure 6). Because it is so readily available for plant production, the threshold concentration that leads to impairment is much lower than TN. Eutrophic conditions begin to occur when nitrate levels reach 150 ppb. Site 1 was well above this mark, but had dropped below a reportable limit by May. NO3 levels remained low or below the reportable limit (10 ppb) for the duration of the sampling period. There are several possible hypotheses for this occurrence. Either the nitrate in the system was used up, and no more was coming in. Or more likely, with temperatures rising, plant production had increased to a level, such that the nitrate in the system was being used as rapidly as it entered the system. The small spikes in June and September may have been the result of the freshening of the system as a result of precipitation (Figure 4). The increased precipitation in May and September would have increased runoff from the watershed and also decreased salinity, resulting in an increase in nitrate and a decrease in marine phytoplankton that would utilize this nitrate.

Figure 6: Nitrate 2005

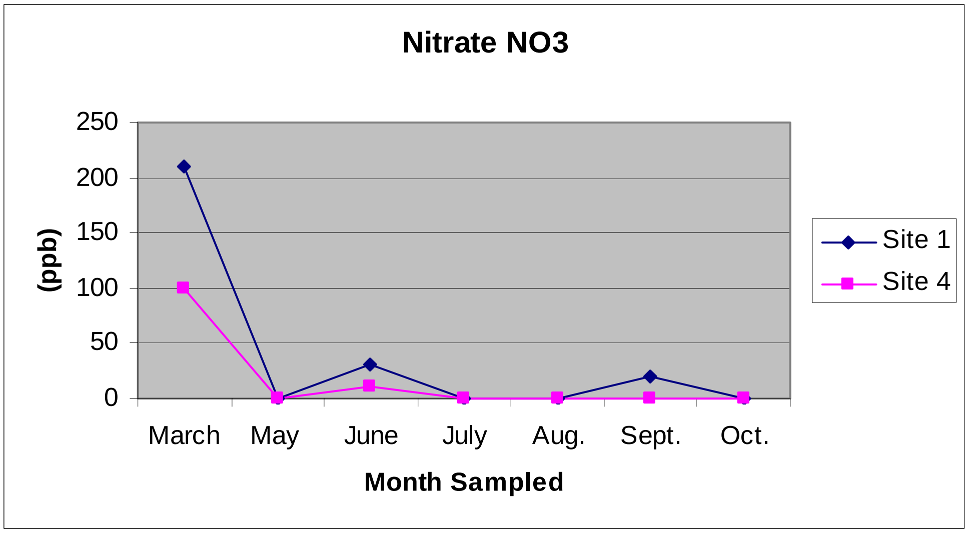
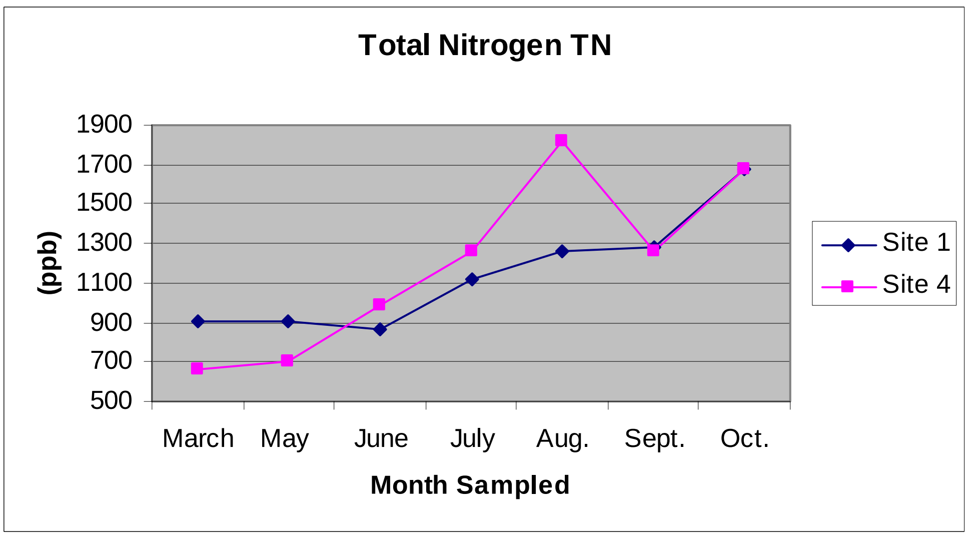


Figure 7: Total Nitrogen 2005



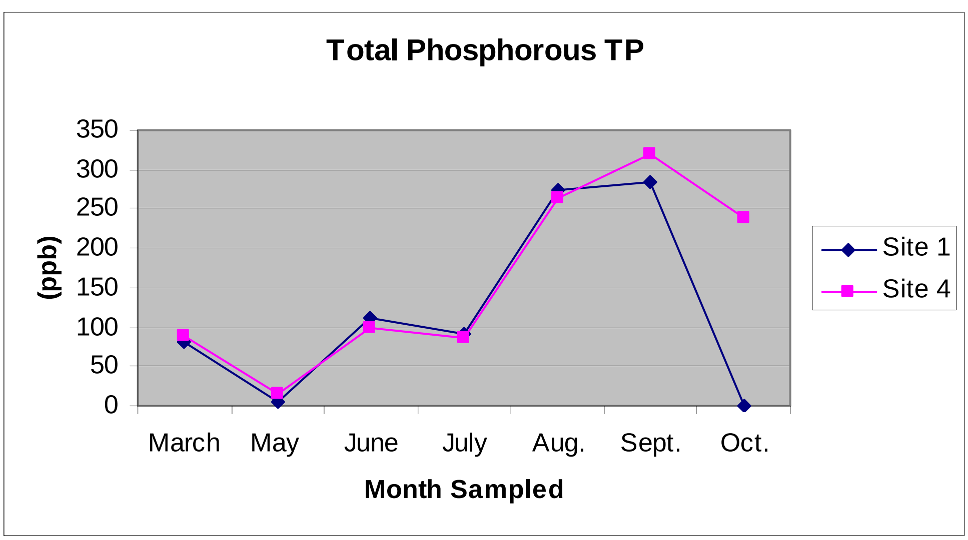
Phosphorous:

Sesachacha Pond is now being maintained as a salt water pond, and as such phytoplankton growth will be limited by nitrogen instead of nitrogen. However, when poor openings occur, and salinity levels drop, phosphorous may become the limiting nutrient to fresh water phytoplankton. It is suggested that for fresh water ponds, a eutrophic condition will begin to occur when TP levels exceed 30ppb. Water quality in Sesachacha has been best when salinity levels have been maintained above 24 ppt. (Town Biologist Reports). It may be that at this high level, the growth of fresh water species of phytoplankton is prohibited, or at least restricted by nitrogen limitation.

When sampling began in March 2005, TP levels were already high, 80 ppb, and 88 ppb at Sites 1, and 4 respectively (Figure 8). At this time, salinity was decreasing, and fresh water inputs were high with 9” of precipitation between March and May. When TP was sampled again in May it had decreased to 6 ppb, and 15 ppb. Perhaps the fresh water inputs had excited a phytoplankton bloom, which had in turn reduced the level of TP in the system. It is also possible, with warming temperatures that the TP had been used up by increases in phytoplankton productivity. Or, perhaps it was a combination of increased precipitation, and increasing temperatures which resulted in an initial decrease in TP.

From June to September salinity leveled out in the pond, and precipitation fell off for most of the summer. During this time period the TP concentration rose dramatically at both stations. The recorded highs were in September with 283 ppb, and 320 ppb at Sites 1, and 4. At these levels, TP was ten times higher than necessary to induce a eutrophic condition. At this level it would most likely be negatively affecting any system, fresh or salt. After September it is interesting to note a dramatic drop in TP, when precipitation picked up again in October; with 6” recorded. This most likely influenced the salinity level to drop to a low of 22 ppt, and probably induced another phytoplankton bloom to occur; decreasing the secchi disc recording to its lowest point of 1.5’. When this freshening occurred, TP decreased to a level below the laboratory detection limit (3 ppb) at Site 1, and at Site 4 the TP decreased by a concentration of 82 ppb. These rapid declines in TP detected, in conjunction with increased precipitation, falling salinity, and phytoplankton blooms must have some association. It may also be that loading drops off when the summer residents leave the Quidnet area, (Site 1) at the end of September; while loading continues to occur on the golf course side of the pond, (Site 4). In any case, TP is so high in Sesachacha, that there must be some substantial loading occurring on both the Quidnet, and golf course side of the pond.

Figure 8: Total Phosphorous 2005



Conclusions:

The water quality of Sesachacha Pond appears to be entirely dependant on the success or failure of the bi-annual openings. Water quality improves when prolonged flushing occurs, and a good exchange with the ocean results in a higher salinity in the pond. However the increased nutrient loading from the watershed, and recycling of nutrients during anoxic events have degenerated water quality to a hyper-eutrophic state. When salinity levels greater than 24 ppt. are not maintained, and substantial flushing does not occur, this salt water habitat declines rapidly. A decline in habitat, and an example of the poor condition the pond is in, can be seen by the pond's phytoplankton dominant plant community. High nutrients, low dissolved oxygen levels, and fish kills will continue to occur if the pond is not properly flushed. If the future health of the pond is to be improved, alternative long term methods of mitigation should be sought after. This is because successful openings can never be guaranteed, as there are too many variables outside our control. Actions that should be initiated would include reductions in fertilizer use, improved methods of filtration for septic systems, and control of stormwater runoff.

Appendix A

Sesachacha Pond 2005

Site 1 Quidnet North Corner
Site 4 Oyster Bed South Corner

Temperature(ºC)

Site 1	3/16/2005	5/5/2005	6/27/2005	7/26/2005	8/17/2005	9/13/2005	10/19/2005
0	2.7	13.8	22	25	24.4	22.4	14.2
3	2.6	13.7	21.8	24.9	24.4	22.3	14.2
6	2.6	13.7	21.6	24.8	24.3	22.1	14.1
9	2.6	13.7	21.5	24.7	24.2	22	14.1
12	2.5	13.6	21.5	24.7	24.1	21.9	14
15	2.5	13.4	21.5	24.6	24	21.9	14
16	2.5		21.3	24.5			

Site 4	3/16/2005	5/5/2005	6/27/2005	7/26/2005	8/17/2005	9/13/2005	10/19/2005
0	2.8	13.6	21.8	24.9	24.4	22.3	14.1
3	2.6	13.5	21.6	24.8	24.4	22.2	14.1
6	2.5	13.4	21.5	24.8	24.4	22	14.1
9	2.5	13.4	21.5	24.7	24.3	21.9	14
12	2.4	13.3	21.4	24.7	24.2	21.9	14
15	2.4	13.2	21.3	24.7	24	21.9	13.9
17	2.4	13.2	21.2	24.6	24	21.9	13.9

Dissolved Oxygen (mg/l)

Site 1	3/16/2005	5/5/2005	6/27/2005	7/26/2005	8/17/2005	9/13/2005	10/19/2005
0	10.73	8.19	5.6	7.19	6	7.1	8.51
3	10.77	8.18	5.77	7.15	5.75	7.07	8.47
6	10.73	8.19	5.43	7.11	5.33	7.02	8.43
9	10.75	8.19	5.4	7.08	5.63	6.78	8.41
12	10.71	8.06	5.27	7.04	5.18	6.44	8.32
15	10.77	7.55	4.96	6.81	4.72	6.3	8.21
16	10.74		4.95	6.78			

Site 4	3/16/2005	5/5/2005	6/27/2005	7/26/2005	8/17/2005	9/13/2005	10/19/2005
0	10.73	8.06	5.8	6.78	6.16	7.13	8.37
3	10.77	8.03	5.75	6.83	6.14	7.18	8.41
6	10.73	8.08	5.68	6.78	5.99	6.84	8.39
9	10.75	8.05	5.6	6.64	5.82	6.57	8.38
12	10.71	7.98	5.59	6.63	5.89	6.51	8.36
15	10.77	7.9	5.18	6.53	5.67	6.62	8.35
17	10.74	7.75	4.49	5.65	2.58	6.34	8.34

Salinity (ppt.)

Site 1	3/16/2005	5/5/2005	6/27/2005	7/26/2005	8/17/2005	9/13/2005	10/19/2005
0	26.9	25.1	23.1	22.7	22.8	23.1	21.8
3	26.9	25.1	23	22.7	22.8	23.1	21.8
6	26.9	25.1	23	22.7	22.8	23.1	21.8
9	26.9	25.2	23	22.7	22.8	23.1	21.8
12	26.9	25.2	23	22.7	22.8	23.1	21.8
15	26.9	25.2	23	22.7	22.8	23.1	21.8
16	26.9	25.2	23	22.7	22.8		

Site 4	3/16/2005	5/5/2005	6/27/2005	7/26/2005	8/17/2005	9/13/2005	10/19/2005
0	26.8	25.1	23	22.7	22.8	23.1	21.8
3	26.8	25.1	23	22.7	22.8	23.1	21.8
6	26.8	25.1	23	22.7	22.8	23.1	21.8
9	26.8	25.1	23	22.7	22.9	23.1	21.8
12	26.8	25.1	23	22.7	22.9	23.1	21.8
15	26.8	25.1	23	22.7	22.8	23.1	21.8
17	26.8	25.1	22.9	22.7	22.8	23.1	21.8

Secchi (ft.)

	3/16/2005	5/5/2005	6/27/2005	7/26/2005	8/17/2005	9/13/2005	10/19/2005
Site 1	4	2.5	2.5	3	2.5	1.5	1.5
Site 4	2	3	3	5	2	1.5	1.5

Nitrate NO3 (ppb)

	3/16/2005	5/5/2005	6/27/2005	7/26/2005	8/17/2005	9/13/2005	10/19/2005
Site 1	210	BRL	30	BRL	BRL	20	BRL
Site 4	100	BRL	10	BRL	BRL	BRL	BRL

Amonia NH3 (ppb)

	3/16/2005	5/5/2005	6/27/2005	7/26/2005	8/17/2005	9/13/2005	10/19/2005
Site 1	BRL	BRL	BRL	BRL	BRL	BRL	BRL
Site 4	BRL	BRL	BRL	BRL	BRL	BRL	BRL

Organic Nitrogen TKN (ppb)

	3/16/2005	5/5/2005	6/27/2005	7/26/2005	8/17/2005	9/13/2005	10/19/2005
Site 1	700	890	840	1,120	1,260	1,260	1,680
Site 4	560	700	980	1,260	1,820	1,260	1,680

Total Nitrogen TN (ppb)

	3/16/2005	5/5/2005	6/27/2005	7/26/2005	8/17/2005	9/13/2005	10/19/2005
Site 1	910	910	870	1,120	1,260	1,280	1,680
Site 4	660	700	990	1,260	1,820	1,260	1,680

Total Phosphorous TP (ppb)

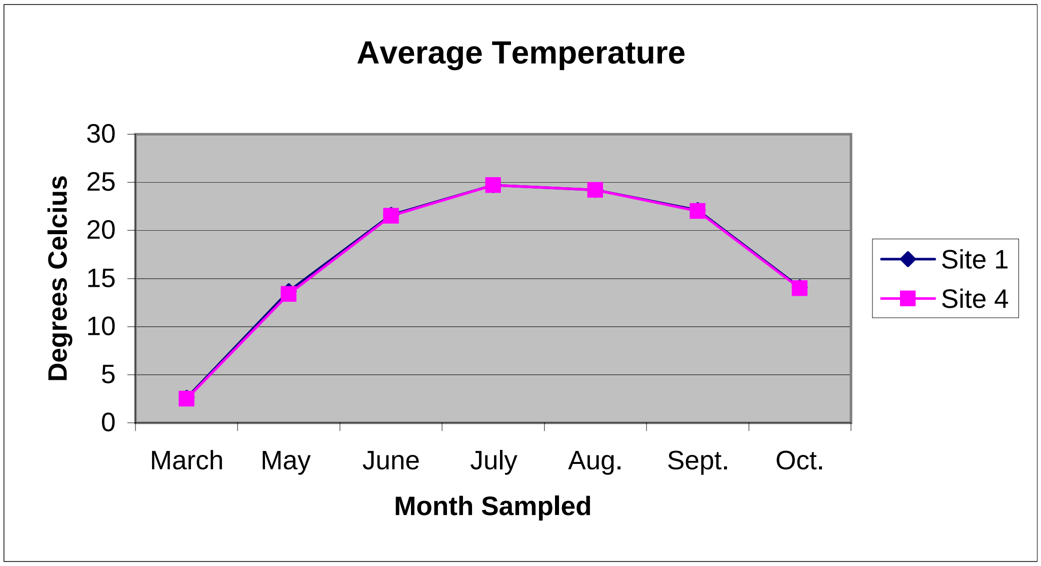
	3/16/2005	5/5/2005	6/27/2005	7/26/2005	8/17/2005	9/13/2005	10/19/2005
Site 1	80	6	111	92	273	283	BRL
Site 4	88	15	99	85	263	320	238

Appendix B

Sesachacha Physical and Chemical Averages 2005

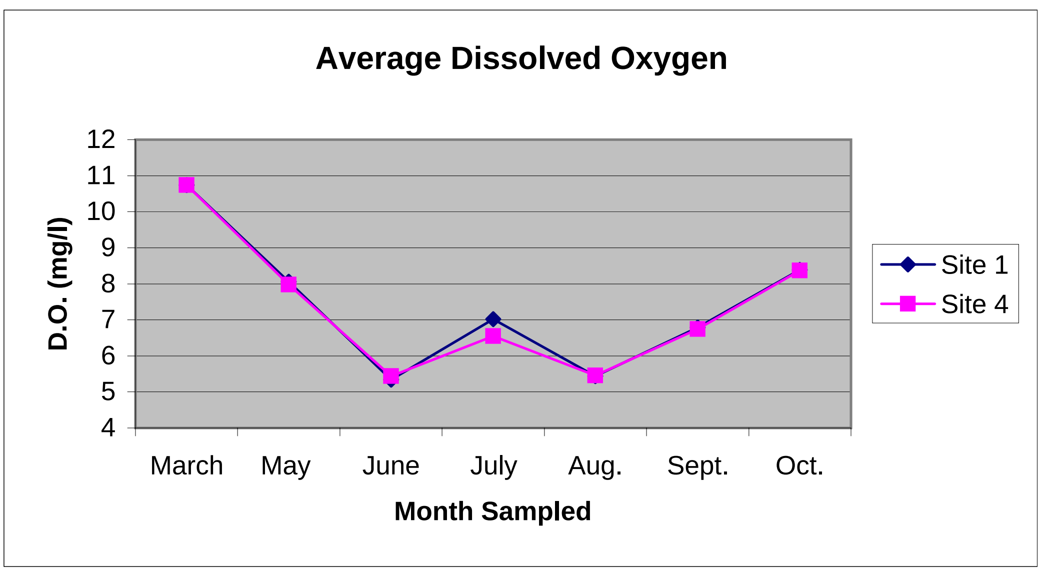
Average Temperatures (ºC)

	March	May	June	July	Aug.	Sept.	Oct.
Site 1	2.6	13.7	21.6	24.7	24.2	22.1	14.1
Site 4	2.5	13.4	21.5	24.7	24.2	22	14



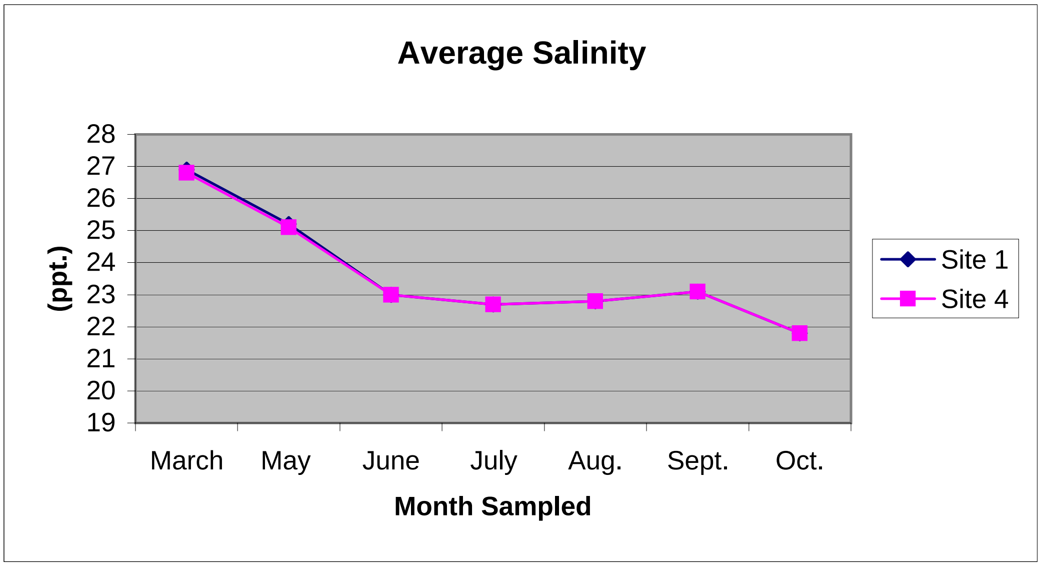
Average Dissolved Oxygen (mg/l)

	March	May	June	July	Aug.	Sept.	Oct.
Site 1	10.74	8.06	5.34	7.02	5.44	6.79	8.39
Site 4	10.74	7.98	5.44	6.55	5.46	6.74	8.37



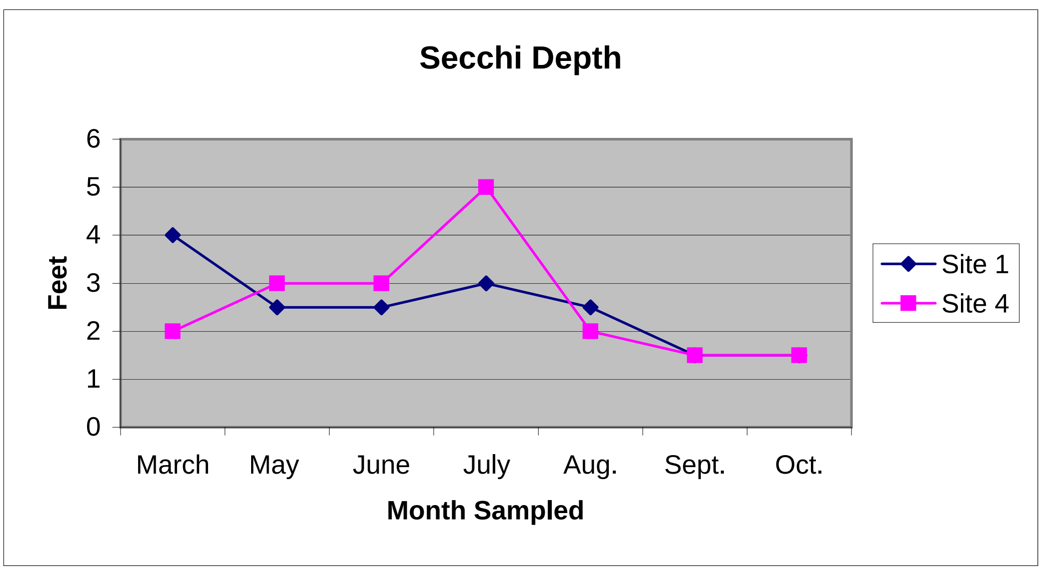
Average Salinity (ppt.)

	March	May	June	July	Aug.	Sept.	Oct.
Site 1	26.9	25.2	23	22.7	22.8	23.1	21.8
Site 4	26.8	25.1	23	22.7	22.8	23.1	21.8



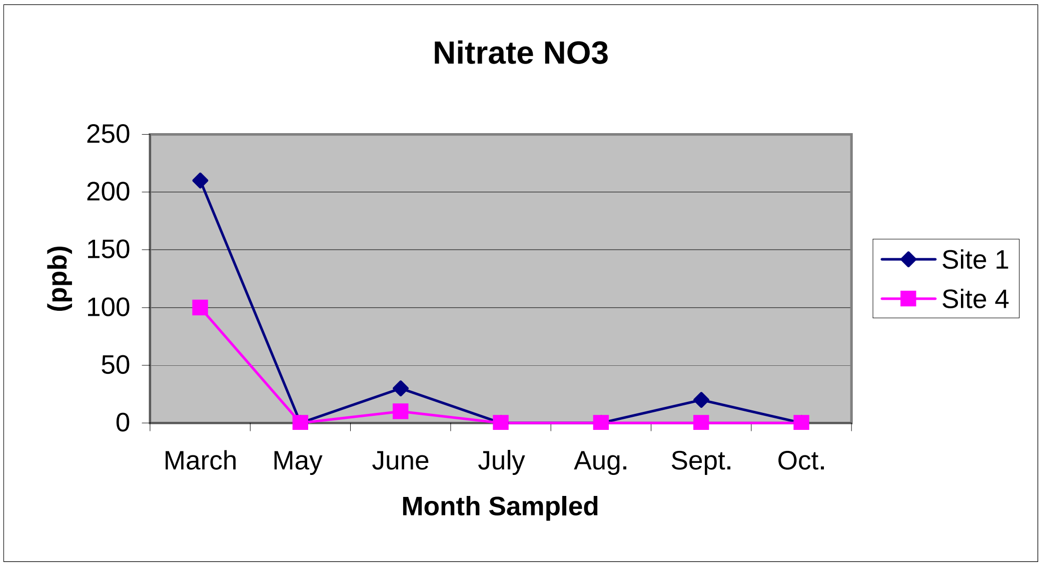
Secchi Depth (ft.)

	March	May	June	July	Aug.	Sept.	Oct.
Site 1	4	2.5	2.5	3	2.5	1.5	1.5
Site 4	2	3	3	5	2	1.5	1.5



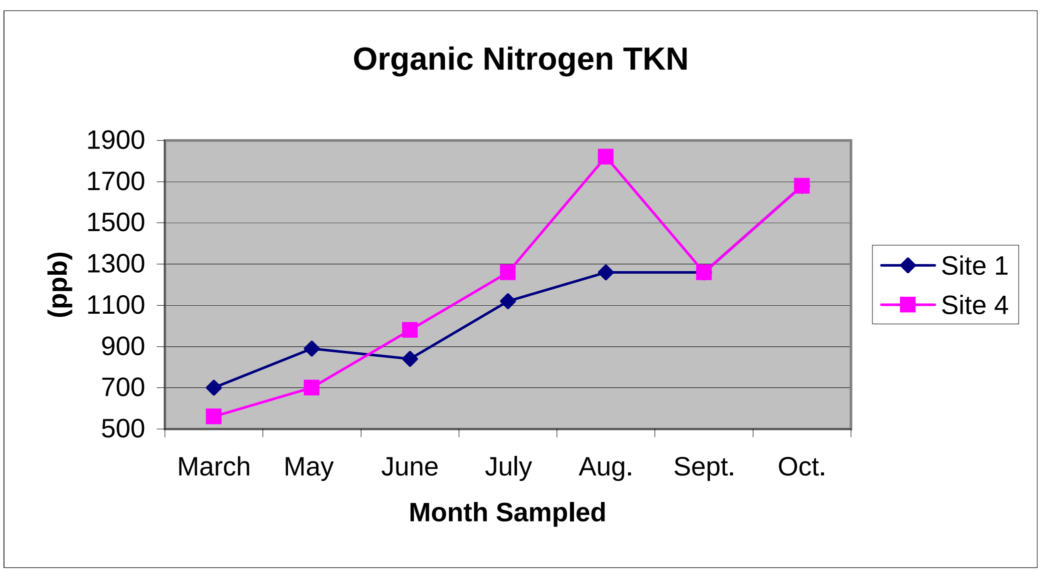
Nitrate NO3 (ppb)

	March	May	June	July	Aug.	Sept.	Oct.
Site 1	210	BRL	30	BRL	BRL	20	BRL
Site 4	100	BRL	10	BRL	BRL	BRL	BRL



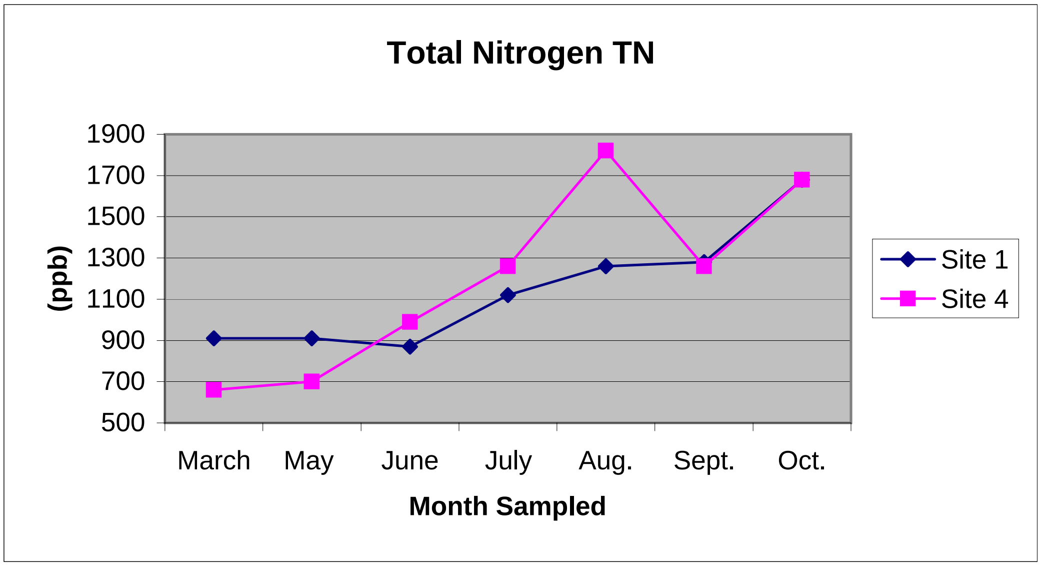
Organic Nitrogen TKN (ppb)

	March	May	June	July	Aug.	Sept.	Oct.
Site 1	700	890	840	1,120	1,260	1,260	1,680
Site 4	560	700	980	1,260	1,820	1,260	1,680



Total Nitrogen TN (ppb)

	March	May	June	July	Aug.	Sept.	Oct.
Site 1	910	910	870	1,120	1,260	1,280	1,680
Site 4	660	700	990	1,260	1,820	1,260	1,680



Total Phosphorous TP (ppb)

	March	May	June	July	Aug.	Sept.	Oct.
Site 1	80	6	111	92	273	283	BRL
Site 4	88	15	99	85	263	320	238